

# *Atmospheric Properties Observed with NAST-I During CRYSTAL-FACE*

The CRYSTAL-FACE Science Team Meeting  
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## NAST-I Performance:

FOV: 130 meters / km alt.

Ground Swath: 13 FOVs

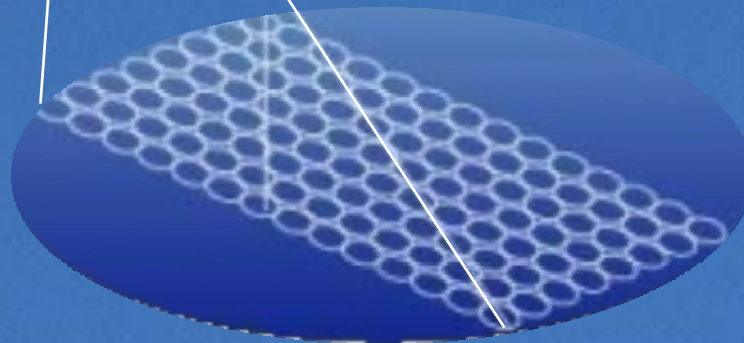
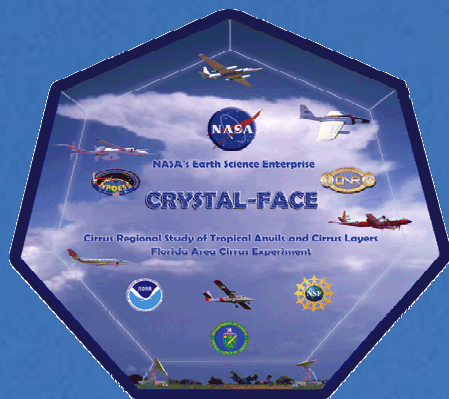
( $\pm 48.2^\circ$ ; 2.3 km / km alt.)

## Spectral Characteristics:

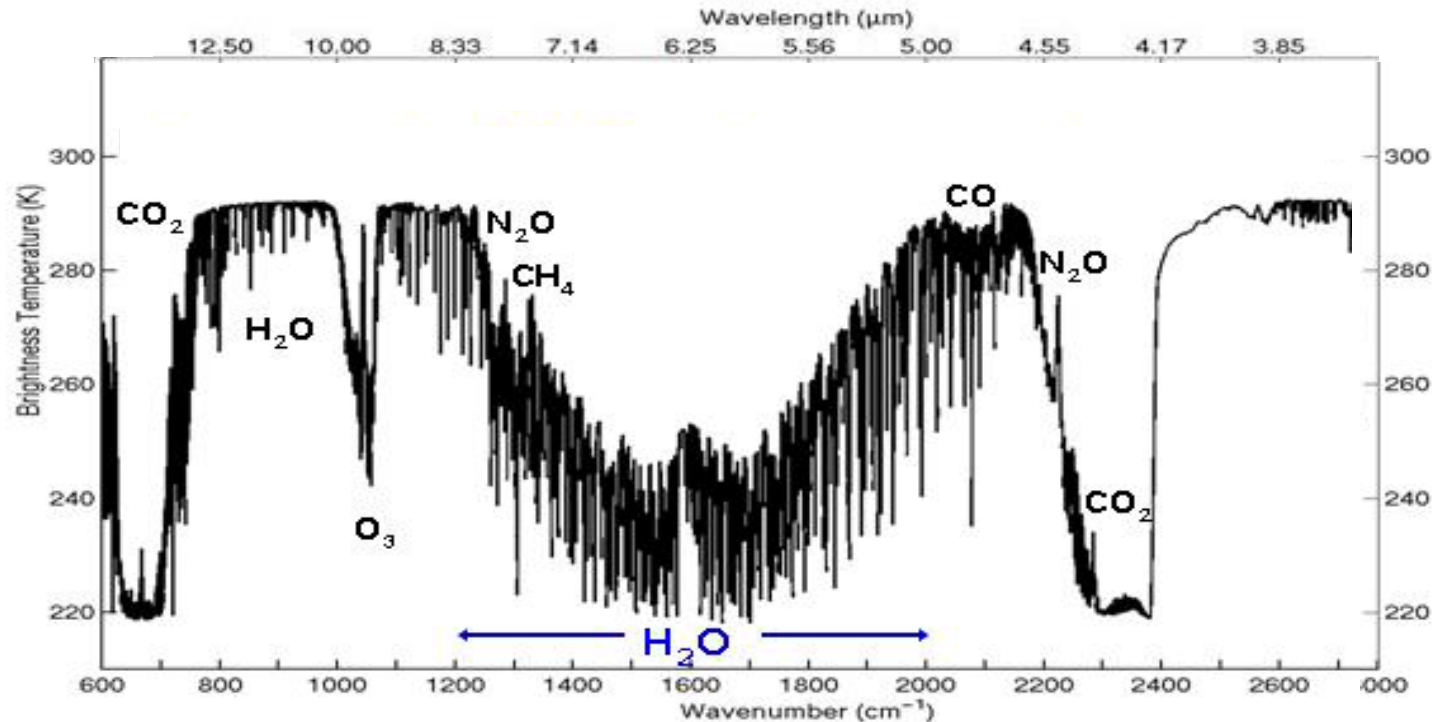
Range: 3.6 – 16.1  $\mu\text{m}$

Resolution: 0.25  $\text{cm}^{-1}$

Channel Number:  $\sim 9000$



# NAST-I IR Measurements and Products



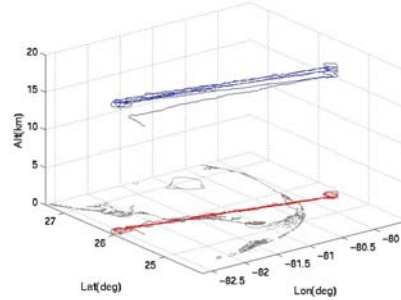
## Products:

Water Vapor and Temperature Soundings  
CO, O<sub>3</sub> concentrations (2-3 Layers)  
Surface Temperature and emissivity  
Cloud top (altitude, optical depth, particle size )

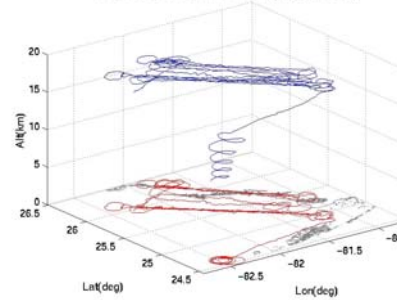
# *Crystal-Face Proteus NAST-I Data Flight Tracks*

Ferry Flight  
(July 1, 2002)

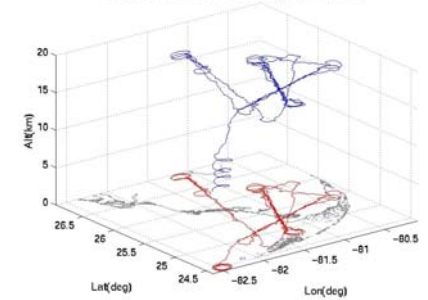
PROTEUS FLIGHT TRACK (July 03, 2002)



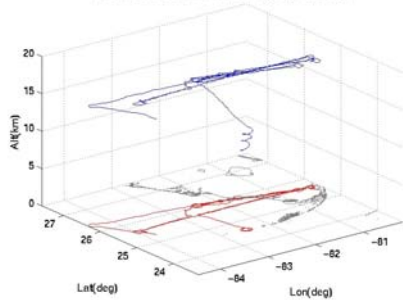
PROTEUS FLIGHT TRACK (July 07, 2002)



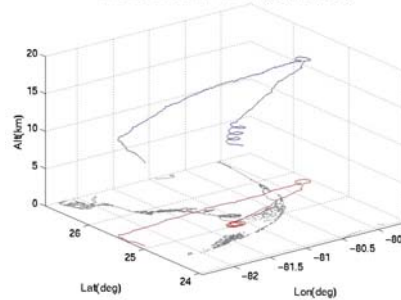
PROTEUS FLIGHT TRACK (July 11, 2002)



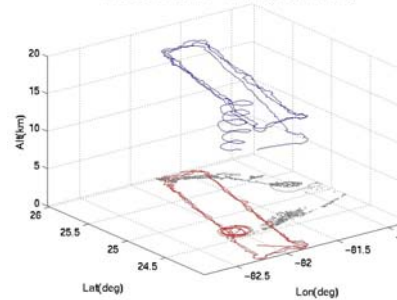
PROTEUS FLIGHT TRACK (July 13, 2002)



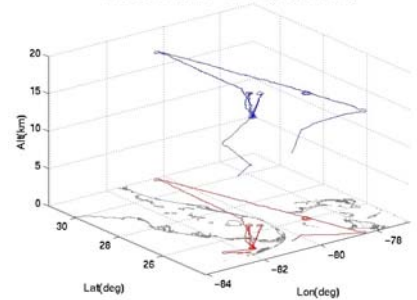
PROTEUS FLIGHT TRACK (July 16, 2002)



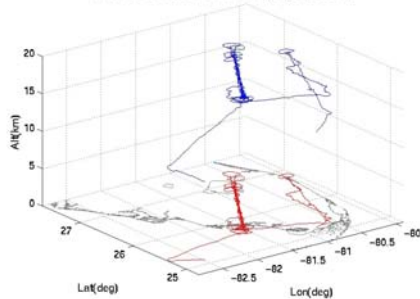
PROTEUS FLIGHT TRACK (July 17, 2002)



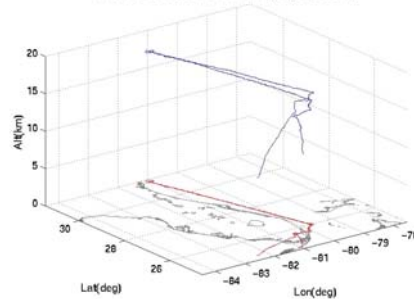
PROTEUS FLIGHT TRACK (July 19, 2002)



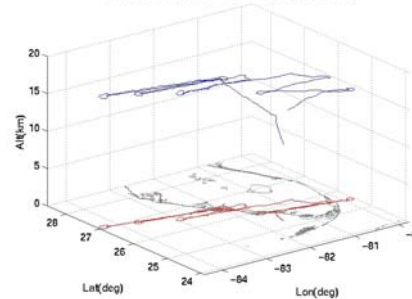
PROTEUS FLIGHT TRACK (July 23, 2002)



PROTEUS FLIGHT TRACK (July 26, 2002)



PROTEUS FLIGHT TRACK (July 29, 2002)



Ferry Flight  
(July 30, 2002)

# Empirical Orthogonal Function (EOF)

## NAST-I Regression Retrieval Algorithm

For clear sky and opaque cloud:

$$R = \varepsilon_{s,c} B_{s,c} \tau_{s,c} - \int_{P_{ac}}^{P_{s,c}} B d\tau - (1 - \varepsilon_{s,c}) \tau_{s,c} \int_{P_{s,c}}^0 B d\tau^*$$

**Radiance EOF  
Amplitudes**

$$C_i = \sum_{j=1}^{nc} R_j E_{ji}$$

$$\left\{ \begin{array}{l} T_s, \\ \varepsilon_s(v), \\ T(p), \\ Q(p) \end{array} \right\} = \sum_{i=1}^{n-1} K_{mi} C_i + K_{mn} P_s \quad \underline{\underline{\text{Retrieval Solution}}}$$

R = radiance

$\varepsilon_{s,c}$  = surface or cloud emissivity

$B_{s,c}$  = surface or cloud Planck radiance

$\tau$  = transmittance between aircraft and atmospheric Pressure level (P)

$\tau_{s,c}$  = atmospheric transmittance between aircraft and surface or cloud ( $P_{s,c}$ )

$\tau^*$  = atmospheric transmittance between surface or cloud P and aircraft

$P_{ac}$  = aircraft pressure

$\mathfrak{R}$  = radiance

E = radiance covariance EOFs

C = radiance EOF amplitudes

T = temperature

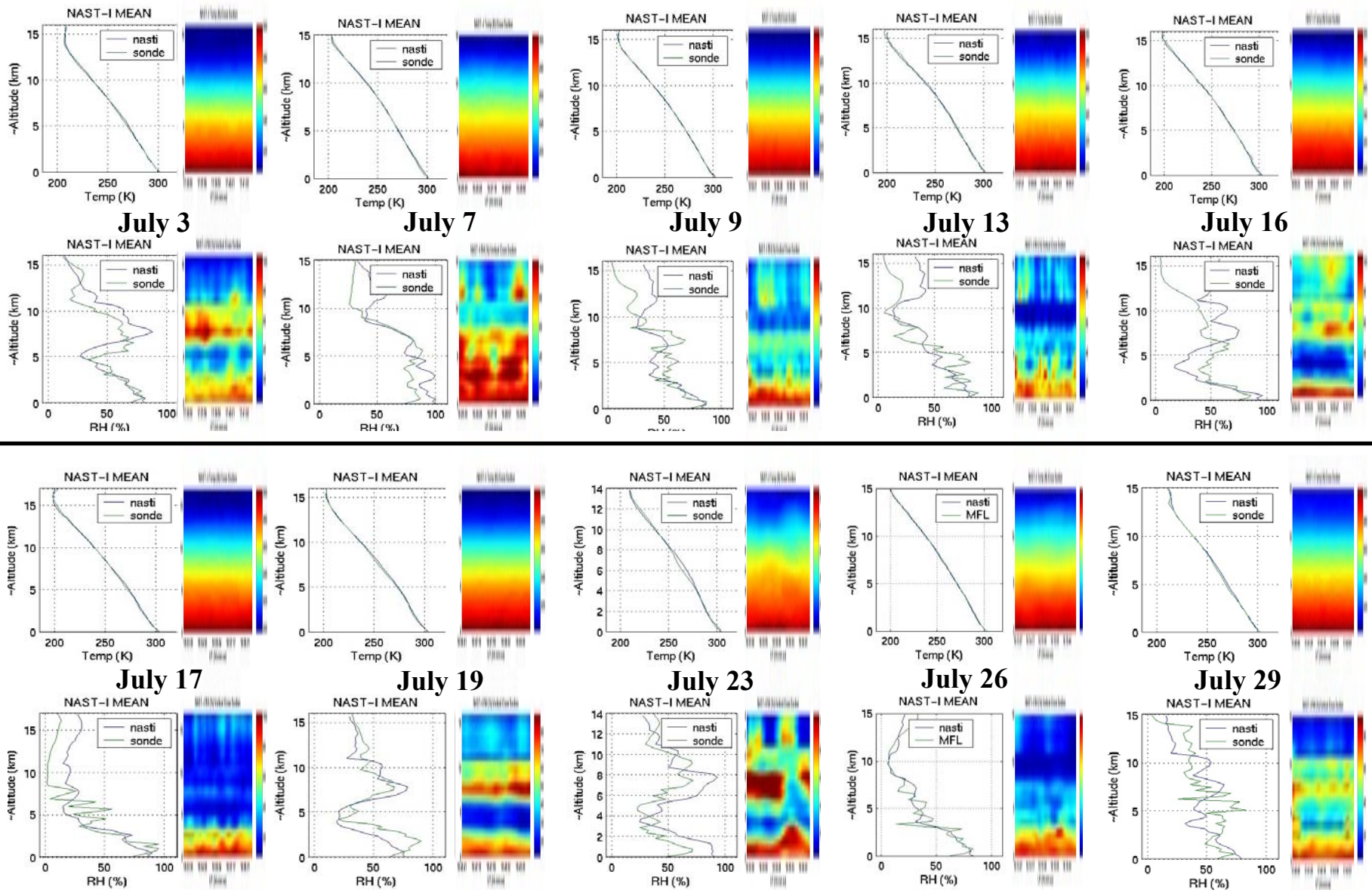
Q = H<sub>2</sub>O mixing ratio

K = regression coefficients

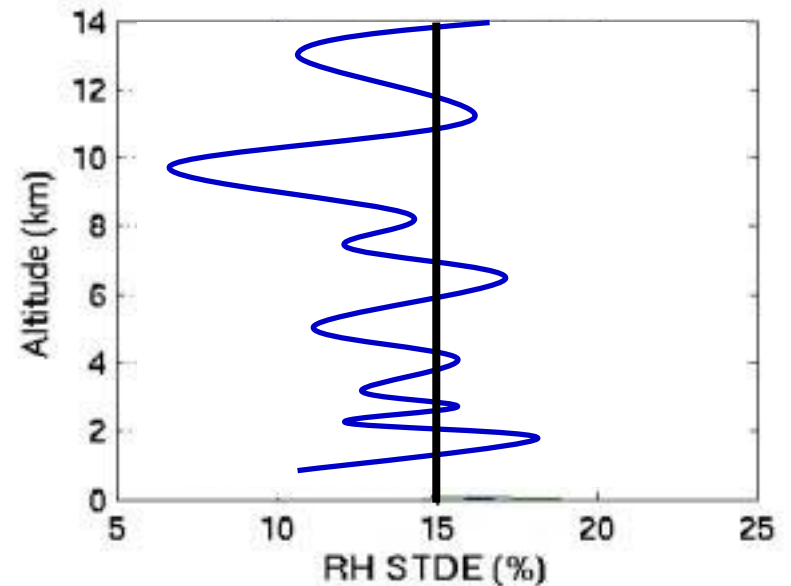
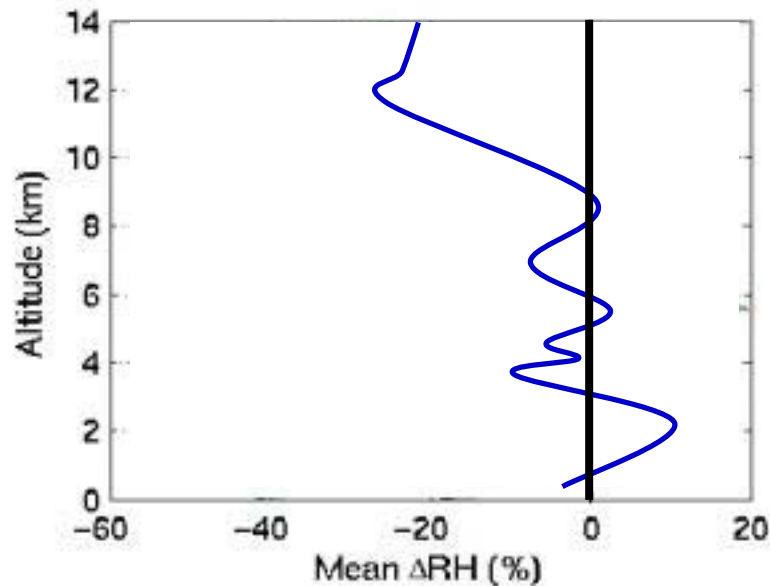
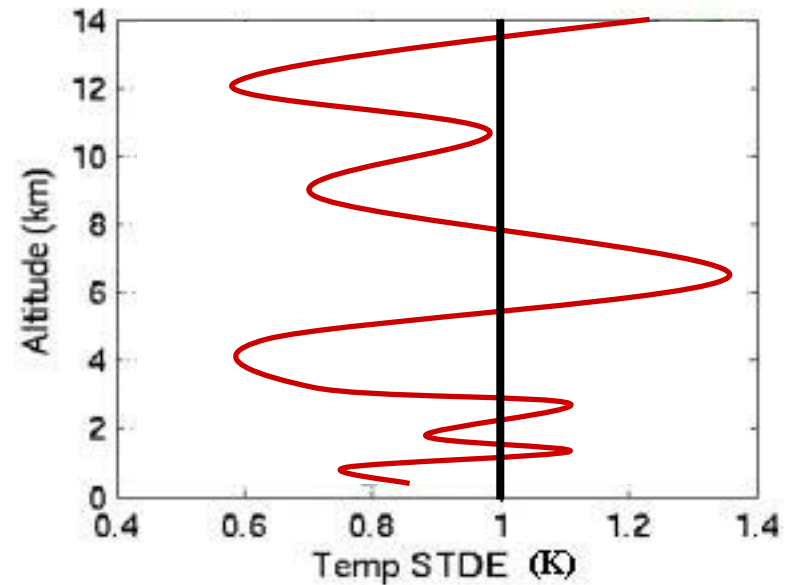
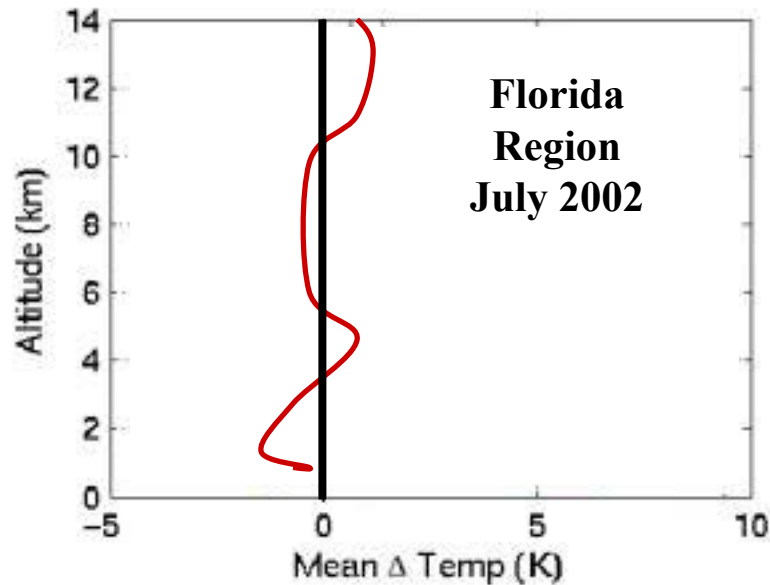
- **Physical Regression – EOFs and regression training based on calculated radiances**
- **Clouds, surface spectral emissivity, skin temp are included in the radiance training**
- **Null radiance errors assumed for PC specification and regression training**
- **Optimal EOF number selected by minimization observed and retrieval radiance**



# C-F Radiosonde Comparisons



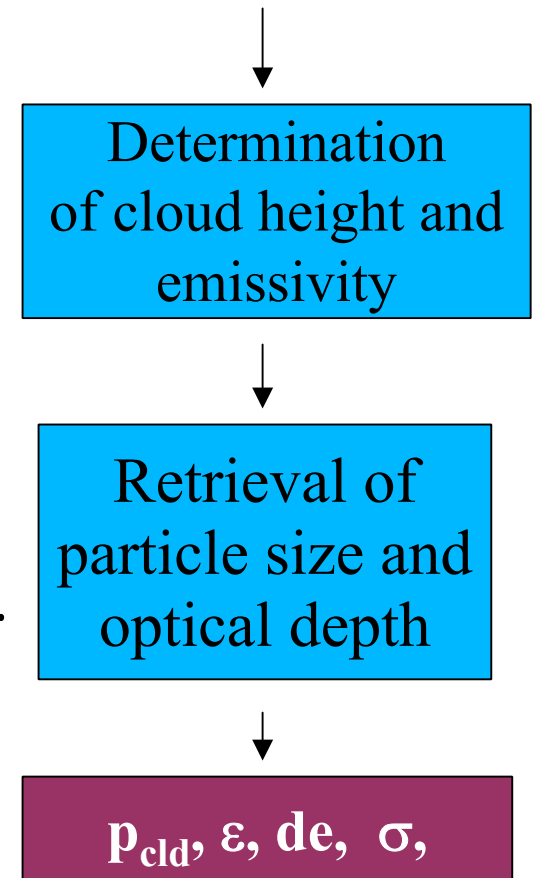
# C-F Retrieval Vs Radiosonde Mean and Stde (10 Cases)



# Cloud Height, Cloud Particle Size, and Optical Depth Retrieval



- The retrieval is based on the comparison between simulated and observed radiances
- Simulated radiances are computed for 18 micro windows between 8.5 and 12 microns
- The cirrus scattering calculations are based on three dimensional randomly oriented ice columns assuming 6 different particle size distributions
- Multiple scattering calculation are performed for 26 different optical thicknesses between 0 and 20
- Cloud pressure is selected as that level in which the spectral variation of calculated emissivity is minimized (i.e., no molecular spectral structure)



FLIGHT TRACK  
JUL 03, 2002

TIME (GMT)

14: 59-15: 02

15: 03-15: 06

15: 07-15: 10

15: 11-15: 14

15: 15-15: 18

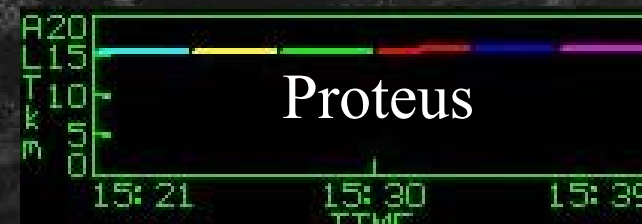
15: 19-15: 22

Proteus@1513

ER-2@1459

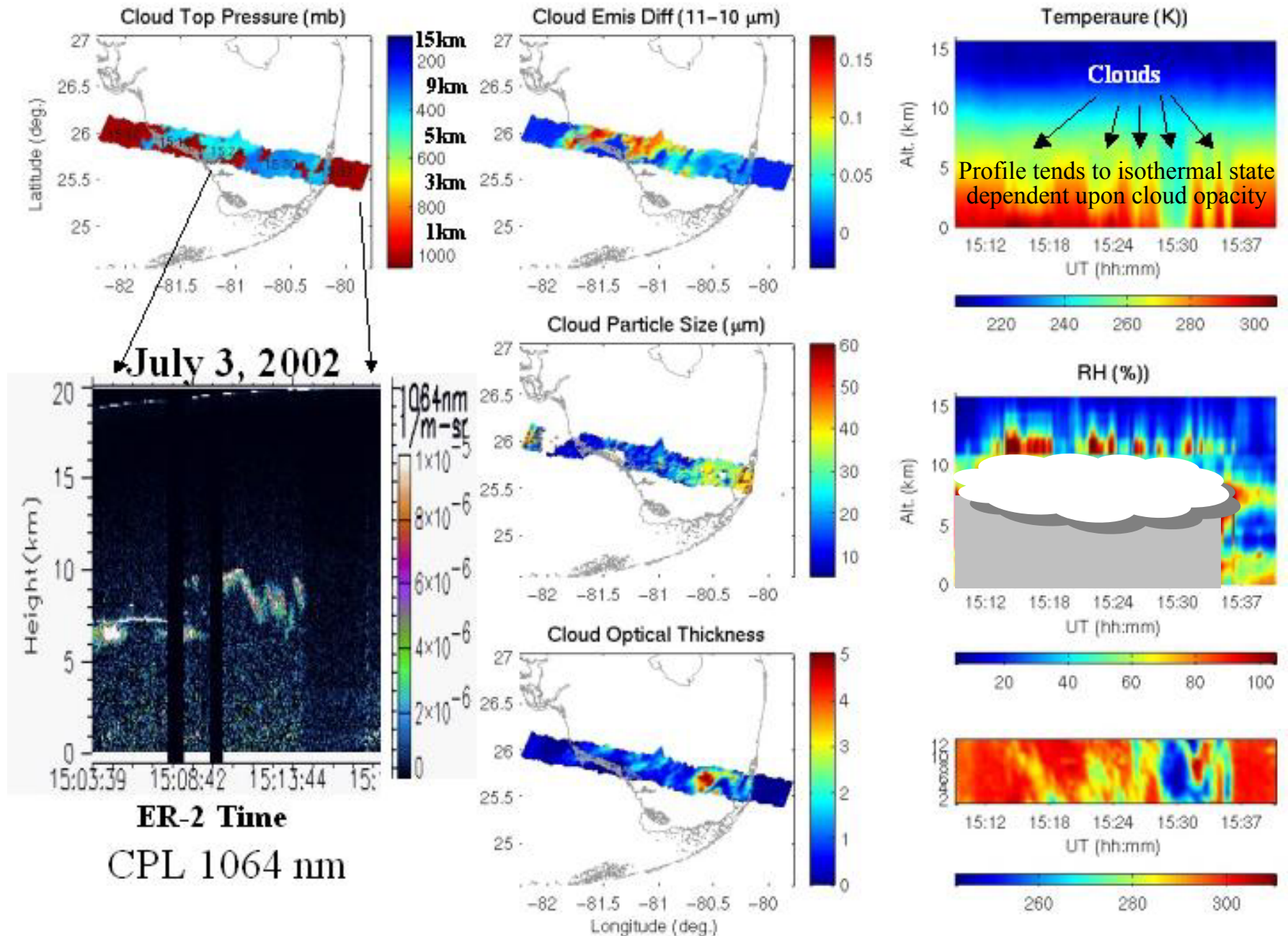
Proteus@1540

ER-2@1519



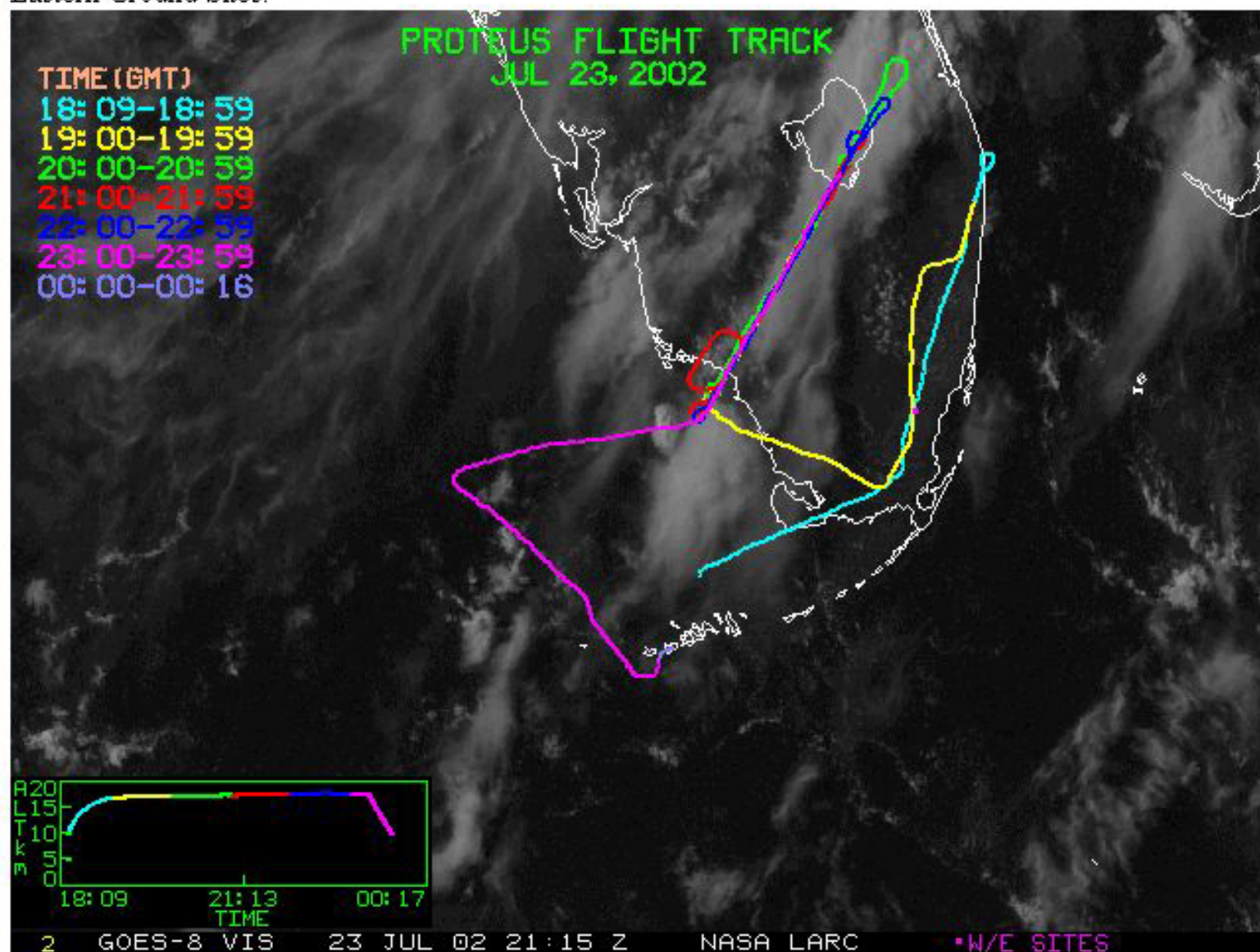


# NAST-I Products and Cloud Physics LIDAR Backscatter



## CRYSTAL-FACE Flight Track Overlay for July 23, 2002

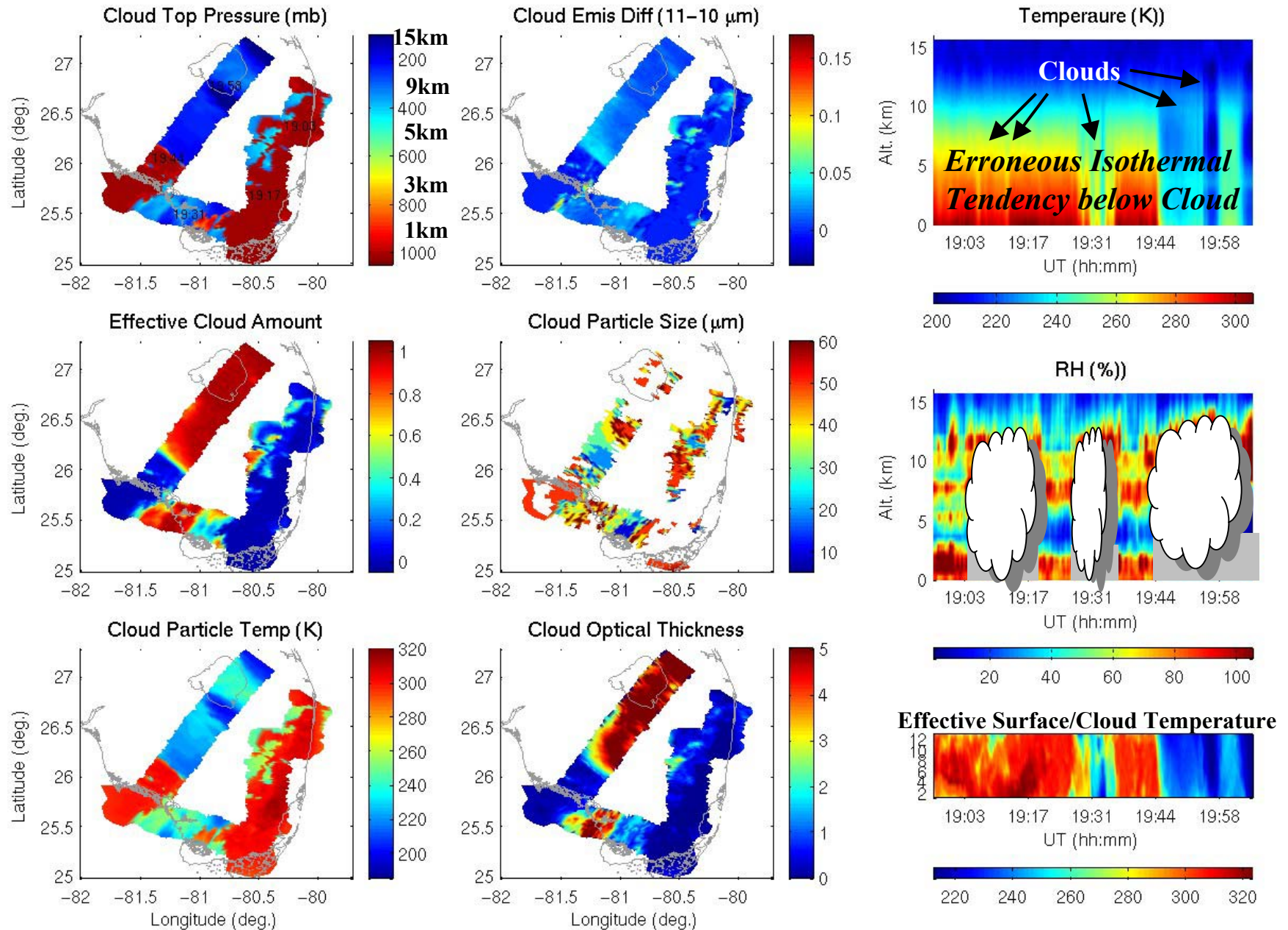
GOES-8 vis image taken on 21:15 UTC July 23, 2002. The Magenta dots marks the Western and Eastern Ground Sites.



- ◆ Flight track segments centered on each GOES VIS image

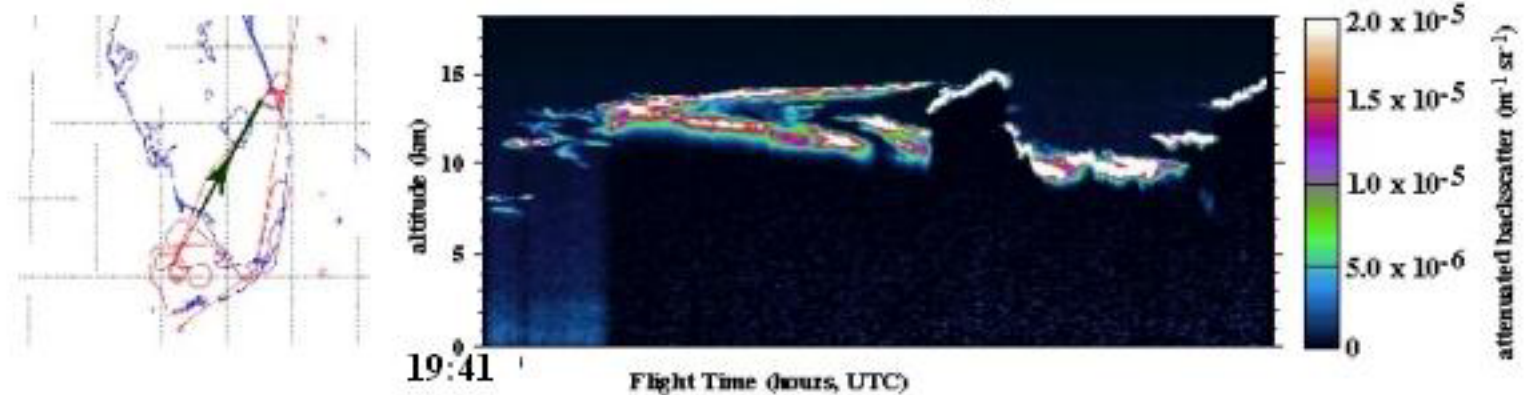


# NAST-I Atmospheric Profile and Cloud Products (7/23/2002)

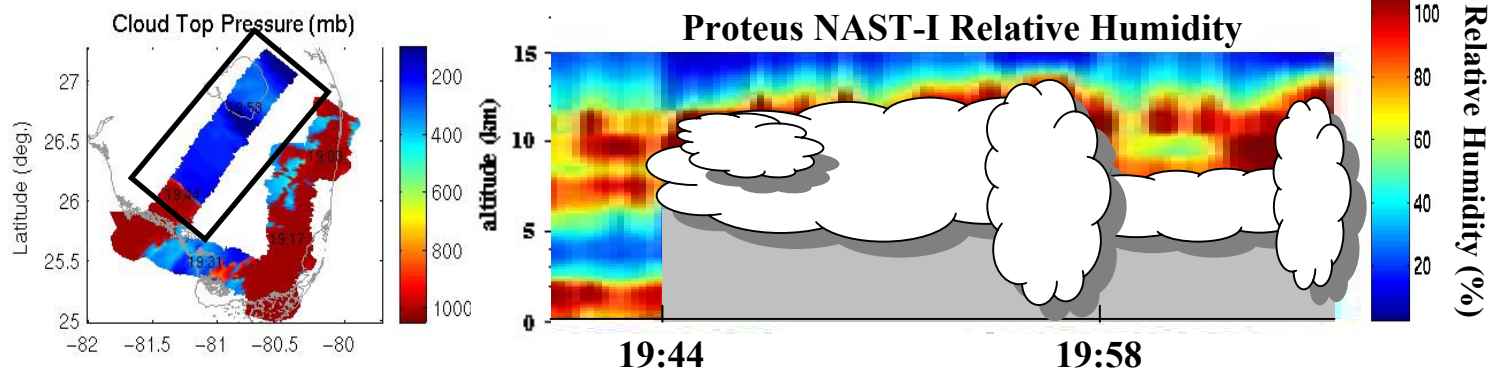
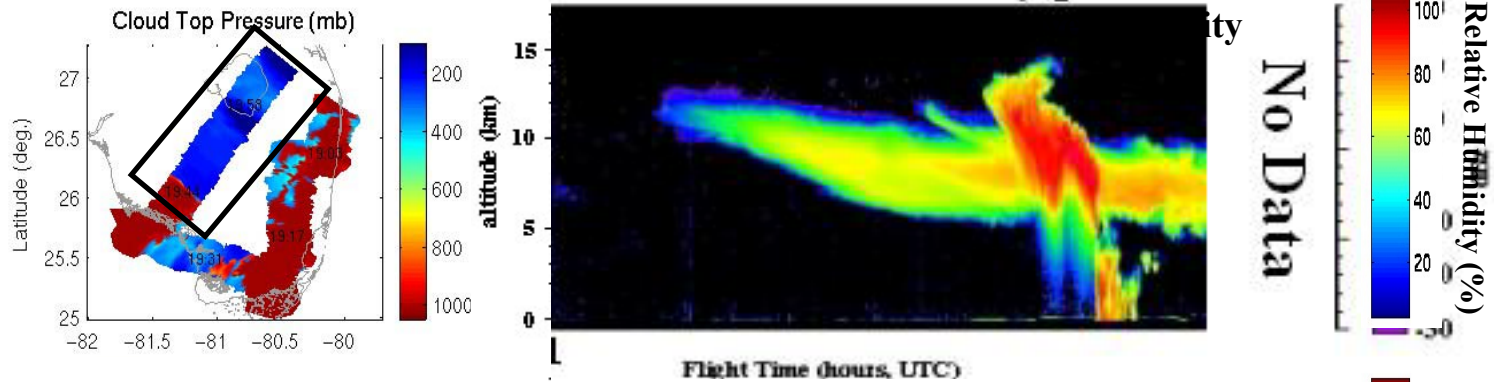


# NAST-I Relative Humidity Vs LIDAR and RADAR (7/23/02)

## CPL 532 nm NRB profiles



## CRS Reflectivity profiles



# Summary

- Initial atmospheric products from the Proteus NAST-I consisting of temperature and moisture profiles, cloud height, emissivity, particle temperature, particle diameter, and optical depth have been submitted to the CRYSTAL-FACE data archive
- Temperature and humidity profiles compare with radiosondes to a Mean and Standard Deviation difference of about 1 K and 15 %, respectively.
- NAST-I derived upper level relative humidity layer observed in clear air adjacent to clouds correlates well with Cloud Physics LIDAR (CPL) cloud top height and 94 GHz Radar (CRS) cloud base height observations
- Final NAST-I products will be rederived, using a recently improved version of the NAST-I radiative transfer model, and submitted to the CRYSTAL-FACE data archive

**Acknowledgement:** The CPL and CRS plots shown here were extracted from the poster by McGill, Havlik, and Hart (this meeting)